Report of Launch Range Safety Committee of the IAASS

Abstract

On May 17-18, 2010, The International Association for the Advancement of Space Safety (IAASS) held the first workshop on public safety from launch risks. Representatives from the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), Centre National d'Etudes Spatiales (CNES), National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and IAASS participated. The workshop was designed as a search for commonality among the risk management approaches used by those space-faring organizations. Much of the foundational material used in developing risk-based methods for the US DoD was identified as a starting point, and 11 fundamental questions that frame the risk management approach were asked and answered by each member of the workshop. The compiled results demonstrate a high degree of commonality among the space-faring organizations, and general harmony in the equivalent levels of safety provided. Future workshops are planned for later in 2010, to move forward in defining further international compatibilities.

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14. ABSTRACT
On May 17-18, 2010, The International Association for the Advancement of Space Safety (IAASS) held the first workshop on public safety from launch risks. Representatives from the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), Centre National dEtudes Spatiales (CNES), National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and IAASS participated. The workshop was designed as a search for commonality among the risk management approaches used by those space-faring organizations. Much of the foundational material used in developing risk-based methods for the US DoD was identified as a starting point, and 11 fundamental questions that frame the risk management approach were asked and answered by each member of the workshop. The compiled results demonstrate a high degree of commonality among the space-faring organizations, and general harmony in the equivalent levels of safety provided. Future workshops are planned for later in 2010, to move forward in defining further international compatibilities.

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Report of Launch Range Safety Committee of the IAASS

Workshop on Public Safety Risk of Launch

May 17-18, 2010

APT SEAC, Huntsville, AL

Tom Pfitzer
Chair, Launch Safety Committee IAASS

Workshop Attendees

Name	Organization
Isabelle Rongier	CNES
Christian Cazaux	Orbital Systems Directorate
François Cahuzac	Launchers Directorate
Xavier Beurtey	European Space Agency (ESA)
Rafael C. Molina	ESA
Masami Miki	Japan Aerospace Exploration Agency (JAXA)
Toru Yoshihara	JAXA
Shinichi Wada	JAXA
Randy Strom	NASA (Wallops)
Paul Wilde	FAA-AST (Houston)
Firooz Allahdadi	U.S. Air Force (Air Force Safety Center)
Bob Baker	U.S. DoD (APT Research)
John Frost	Moderator
Tom Pfitzer	Chair, Launch Safety Committee

1st IAASS Workshop on Harmonizing Launch Safety

Xavier Beurtey, ESA

Paul D Wilde
Paul Wilde,
FAA-AST (Houston)

Randy Strom,
NASA (Wallops)

和田伸一
Shinichi Wada
Shinichi Wada, JAXA

Rafael C. Molina, ESA

Isabelle Rongier, CNES

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Yoshihara Toru, JAXA

Masami Miki
Masami Miki, JAXA

Christian Cazaux,
Orbital Systems Directorate

François Cahuzac
François Cahuzac,
Launchers Directorate

Goal of Launch Range Safety Committee

- Encourage and support an international framework of experienced range safety professionals to advance the discipline of launch range safety by
  - Use of scientific methods
  - Understanding risks
  - Collaboration on common issues
  - Harmonizing standards and practices

Management of Launch & Re-entry Risk Workshop

Background

- Space mission risks are often of international nature in the sense that an operator may pose risks to overflown populations. There is currently, however, no international forum to facilitate exchanging experiences on risk management and relevant assessment methods and tools.

Purpose

- Provide a forum to interchange information and identify areas of consensus on providing public safety for space launch and re-entry.

Approach

- Address a variety of approaches used by focusing on 11 questions for each agency responsible to provide launch/re-entry safety.

Goal

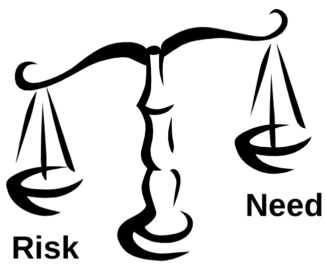
- Determine areas of consensus.
- Determine areas for future collaboration.
- Provide out-brief on progress to conference.

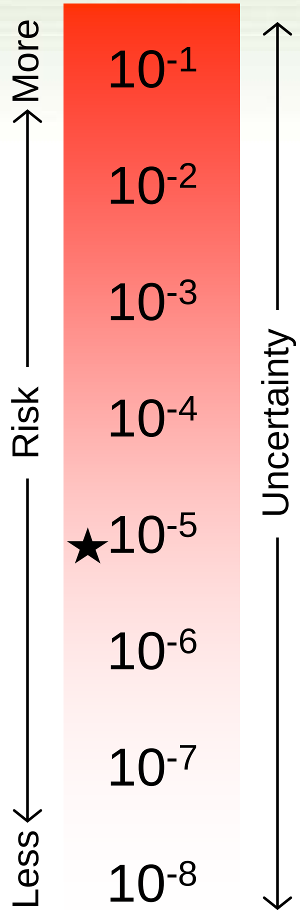
Key Elements of a Risk-based Approach

1. How is "safe enough" defined or determined?

1. Specify safety criteria.

Criteria:
How safe is safe enough?
- Social science
- Legal considerations
- Comparative analyses





2. How is the safety of this launch or re-entry assessed?

2. Specify quantitative risk assessment.

Modeling:
How should modeling safety requirements be calculated?

- Physical science
- Technical assumptions
- Technical approaches
- Biases
  (worst case ←→ self-interest)

3. Combining criteria and modeling provides the highest assurance of fair and impartial governance. Also: better credibility, lower cost, time saver.

Key Elements of a Risk-based Management Approach

A commonly used approach by many organizations in managing risks is the I-A-R-A approach.

Identify Risk Factor
(what poses a risk?)

→ **A**ssess Risks

↓ **R**educe Risks

← **A**ccept Risks

3. How are risk factors identified for launch safety?

4. How are assessments conducted?

5. What numerical metrics are used to assess risk?

6. What approaches are used to reduce risk?

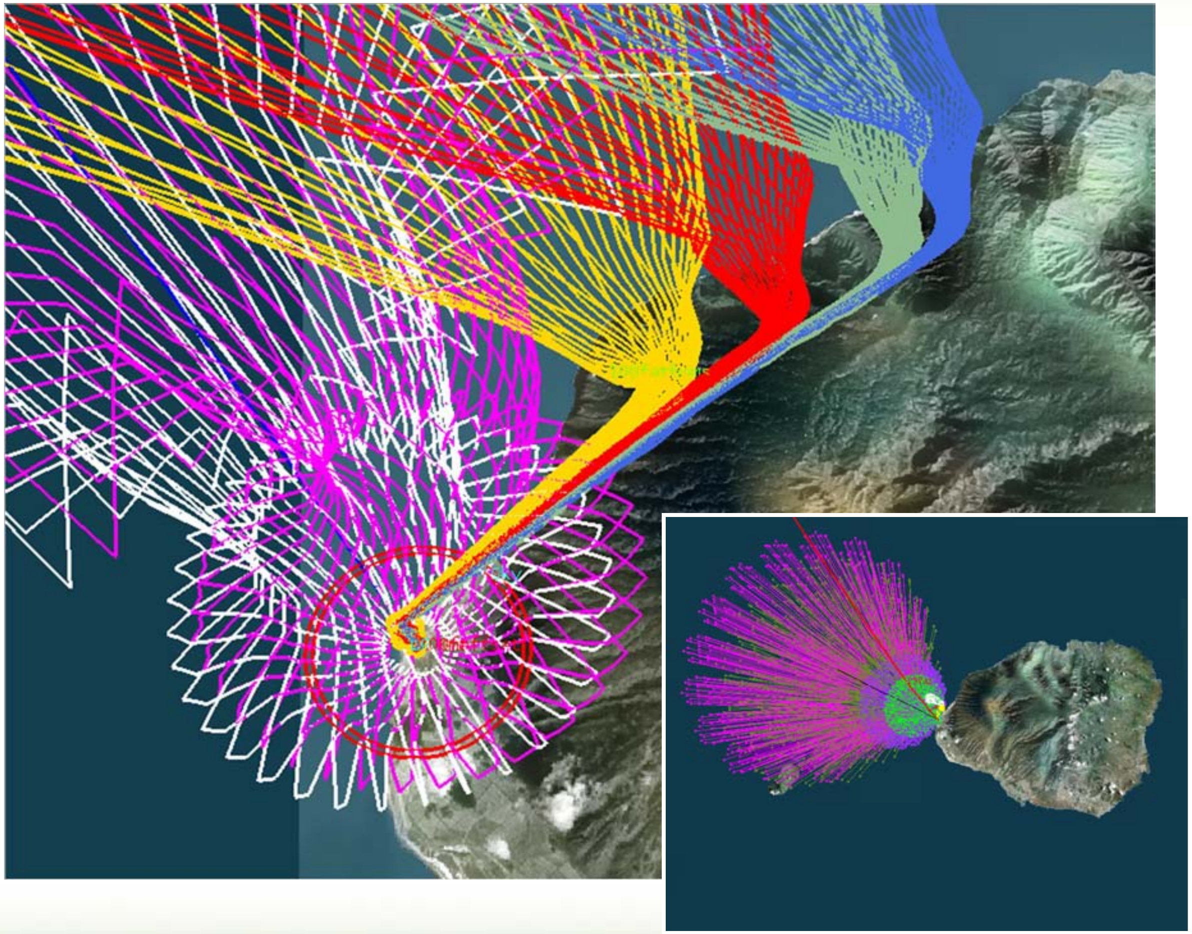
7. How and who accepts the risk?

Risk Modeling

8. What computer modeling approaches are used?

Characteristics

- Nominal malfunction trajectories
- Runge Kutta trajectories
- Aggregate probabilities
- Standardized population models using population densities
- Pre-real time

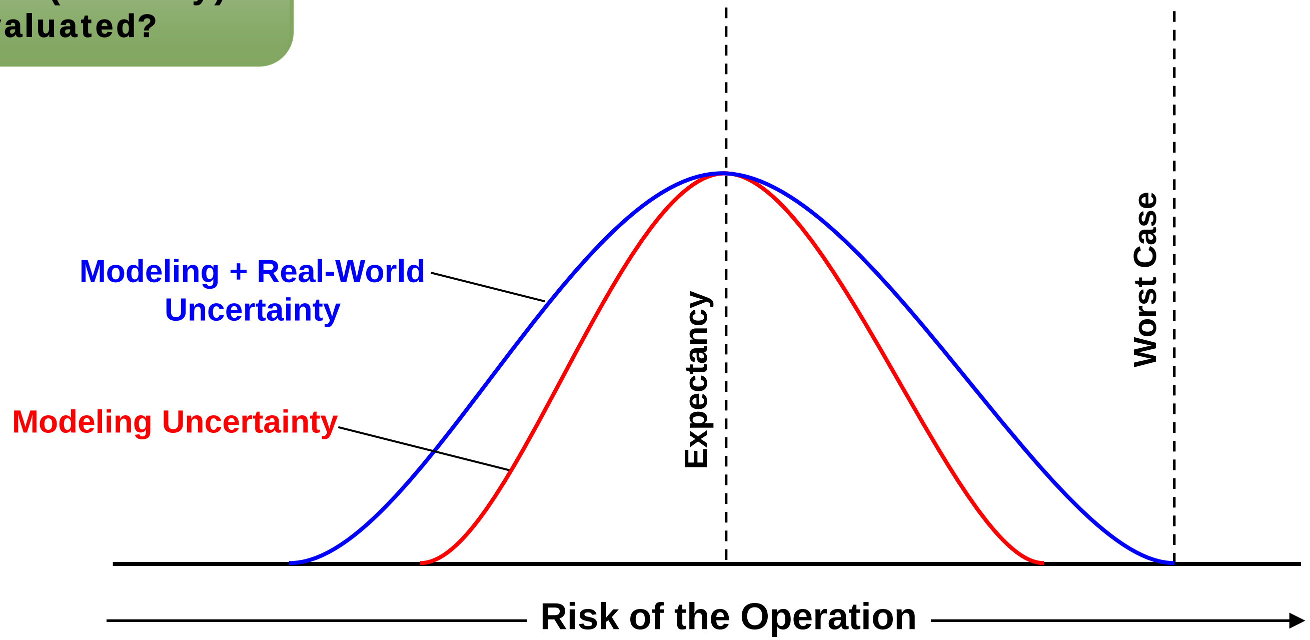


Uncertainty in Risk Assessments

9. How are risk uncertainties treated?

10. How are modeling (epistemic) uncertainties and real-world (aleatory) variations evaluated?

11. What statistical confidence level is used in the calculations feeding the risk acceptance decision?



Summary of Answers to Question 1. How is "safe enough" defined or determined?

- Comparative Risks and Accident Experience are used to define the quantitative limits

- Numerical criteria documented and publicly available

- ALARP is applied

- As low as possible (ALAP) is policy

Unanimous

Consensus

Important minority

Summary of Answers to Question 2

How is the safety of this launch or re-entry assessed?

- Trajectory normal & 3-sigma
- Malfunction Turn
- Debris Analysis
- FTS Analysis

- The operator must demonstrate the safety of the operation that he conducts.
- Perform either independent assessment (technical expertise, crosscheck studies) and continuous monitoring of operations.
- In the open discussion to the public, the discussion focuses on how it could accomplish a safe launch/reentry.
- Numerical Analysis, Based on Nominal/Failure Events, Populations, Atmospheric Expectations, Vulnerability etc.

Unanimous

Consensus

Important minority

Summary of Answers to Question 3
How are risk factors identified for launch safety?

- System Safety Analyses (HA, PHA, FMEA, etc.)

- Risk Formula
- Probabilities: Industry data & history

- Prevention based on reliability
- Quantitative risk assessments are used to identify the risk drivers (dominant sources)
- Probability of Nominal/Off nominal Events along with the hazards of those events to Both Public and Government Individuals/Assets

Unanimous

Consensus

Important minority

Summary of Answers to Question 4
How are assessments conducted?

- In accordance with a Risk Management Process Identify Assess Reduce Accept (IARA)

- Demonstration of the compliance with qualitative and quantitative objectives is made by the operator.
- Verification by government. Perform specific audit or independent assessment
- Risk management is used during design and fabrication

Unanimous

Consensus

Important minority

Summary of Answers to Question 5
What numerical metrics are used to assess risk?

- Probability of Impact (e.g. point estimates or distribution)

- Probability of casualty (e.g. point estimates or distribution)
- Probability of Victim (at least 1 casualty, e.g. point estimates or distribution)
- Probability of Injury (e.g. point estimates or distribution)
- Probability of Fatality (e.g. point estimates or distribution)
- Expected Casualties (NOT a probability)
- Expected Casualties (summations of probabilities)

Unanimous

Consensus

Important minority

Summary of Answers to Question 6
What approaches are used to reduce risk?

- Trajectory design
- Structural breakup
- Flight Safety System design
- Flight Termination System design operation
- Evacuation
- Sheltering
- Collision Avoidance for inhabited space vehicles

- Goal: Risk analysis to be included as soon as possible in the preparation studies, beginning at feasibility phase, risk reduction measures must be identified and implemented through risk control plans.

- Operational Site selection
- Collision Avoidance for inhabited and all active satellites space vehicle
- Design/Launch Window Exclusions
- Containment where practical

Unanimous
Consensus
Important minority

Summary of Answers to Question 7

How and who accepts the risk?

- A formalized process

- Designated Government Official

- The operator is responsible for the safety of the operation.
- Government verifies the technical conformity to the regulations.
- Risks above the published criteria would require a waiver approved by Government.

Unanimous

Consensus

Important minority

Summary of Answers to Question 8
What computer modeling approaches are used?

- Monte Carlo techniques
- Separate accreditation desired
- Continuous improvement of the tools (update after ground test or flight results, research program results, etc.)

- Multiple independently developed tools

- In-house Tools

Unanimous

Consensus

Important minority

Summary of Answers to Question 9
How are risk uncertainties treated?

- Best practices maturing

- A conservative approach on data and models. For high consequence events, a worst case analysis can be performed.
- For nominal and 3 sigmas behavior: biases and dispersions are applied to both input data.
- Assuming realistic worst-cases.
- Best practices maturing
- Best accuracy is 1/2 order of magnitude
- Target Expected Value. Where There Is Uncertainty Ensure Obviously Conservative

Unanimous

Consensus

Important minority

Summary of Answers to Question 10.

How are modeling (epistemic) uncertainties and real-world (aleatory) variations evaluated?

- Epistemic & aleatory uncertainties are considered, not always quantified
- Sensitivity analysis are routinely performed
- Make conservative assumptions to offset uncertainties

- Perform sensitivity analysis of input assumptions. Model results comparisons, Monte Carlo analysis

Unanimous

Consensus

Important minority

Summary of Answers to Question 11.

What statistical confidence level is used in the calculations feeding the risk acceptance decision?

- Expected value

- (50%) with minimal assumptions biasing answer to safe side.
- Statistical confidence level of 60% for probabilistic assessment, with minimal assumptions biasing answer to safe side.
- 50% Confidence Level is the goal however worst-case inputs are used when limitations/impacts are minor to the project objectives.
- Point estimate with assumptions biasing answer to safe side.

Unanimous

Consensus

Important minority

Common Risk Equation

$$\text{Risk} = \sum \text{Probability of hazardous event} \times \text{Undesired consequence} \times \text{Exposure}$$

- All events
- All consequences
- All exposures
- All life cycle phases?

Findings

- Collaboration provides many benefits
  - Confidence in methods, criteria, approaches
  - Areas of harmony have been identified
  - A source of independent validation
- A high degree of consensus was found in answering all eleven questions
  - Very many more similarities than differences
- Launch safety and re-entry safety have very many identical aspects making joint collaboration beneficial

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Summary

- A collegial and professional working relationship was established among international range safety professionals
- Top level consensus provides a foundation for deeper examinations
- All participants benefit substantially from the insights provided and examination of alternative methods

The 1st IAASS Workshop on Launch Safety proved highly successful